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(54) COMMON CONTROL TELECOMMUNICATION SWITCHING SYSTEM

(57) In a processor-controlled telecommunications exchange, to avoid overloading the computer the number of call attempts per unit time is checked at clock intervals and limited. A prediction unit assesses from the call distribution and the mix of call types the expected computer occupancy and on the basis of those predictions fixes the number of call attempts to be accepted.

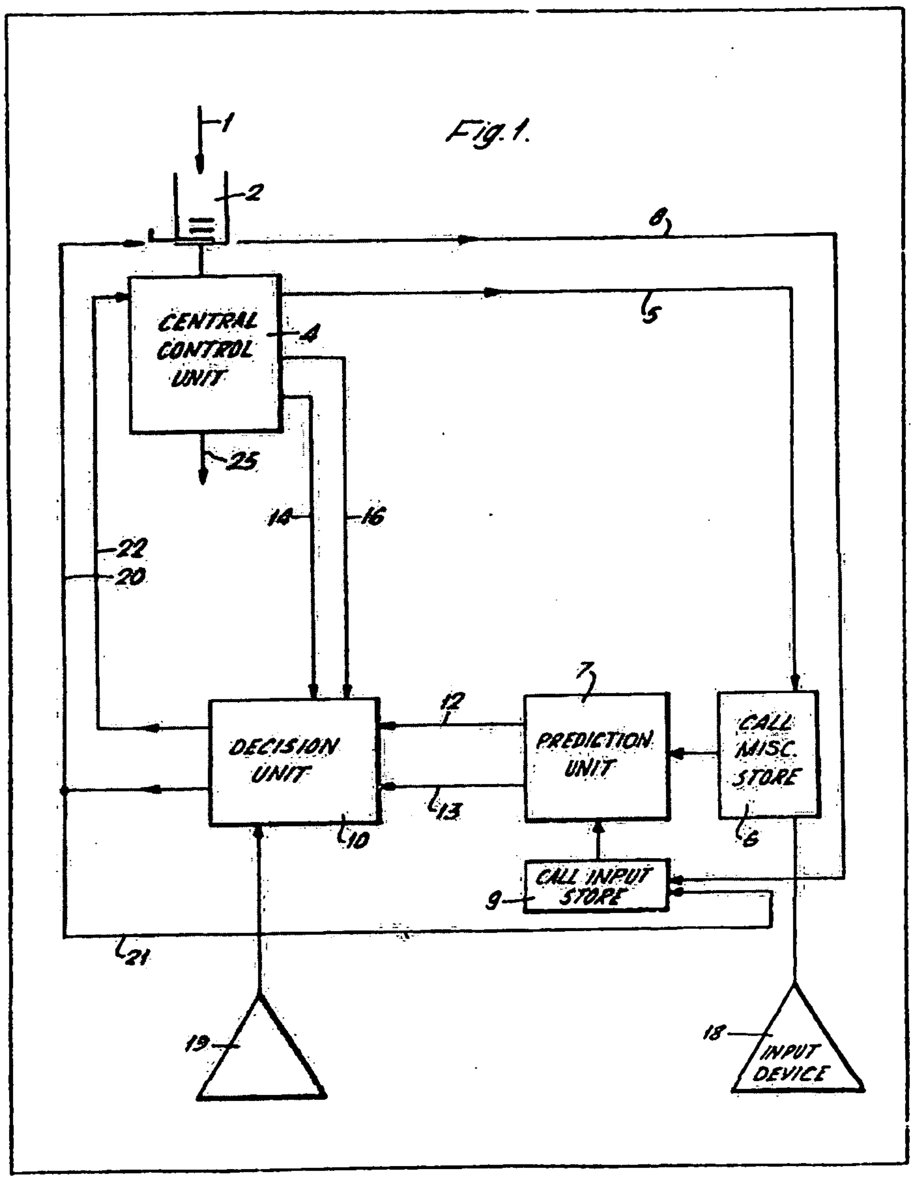

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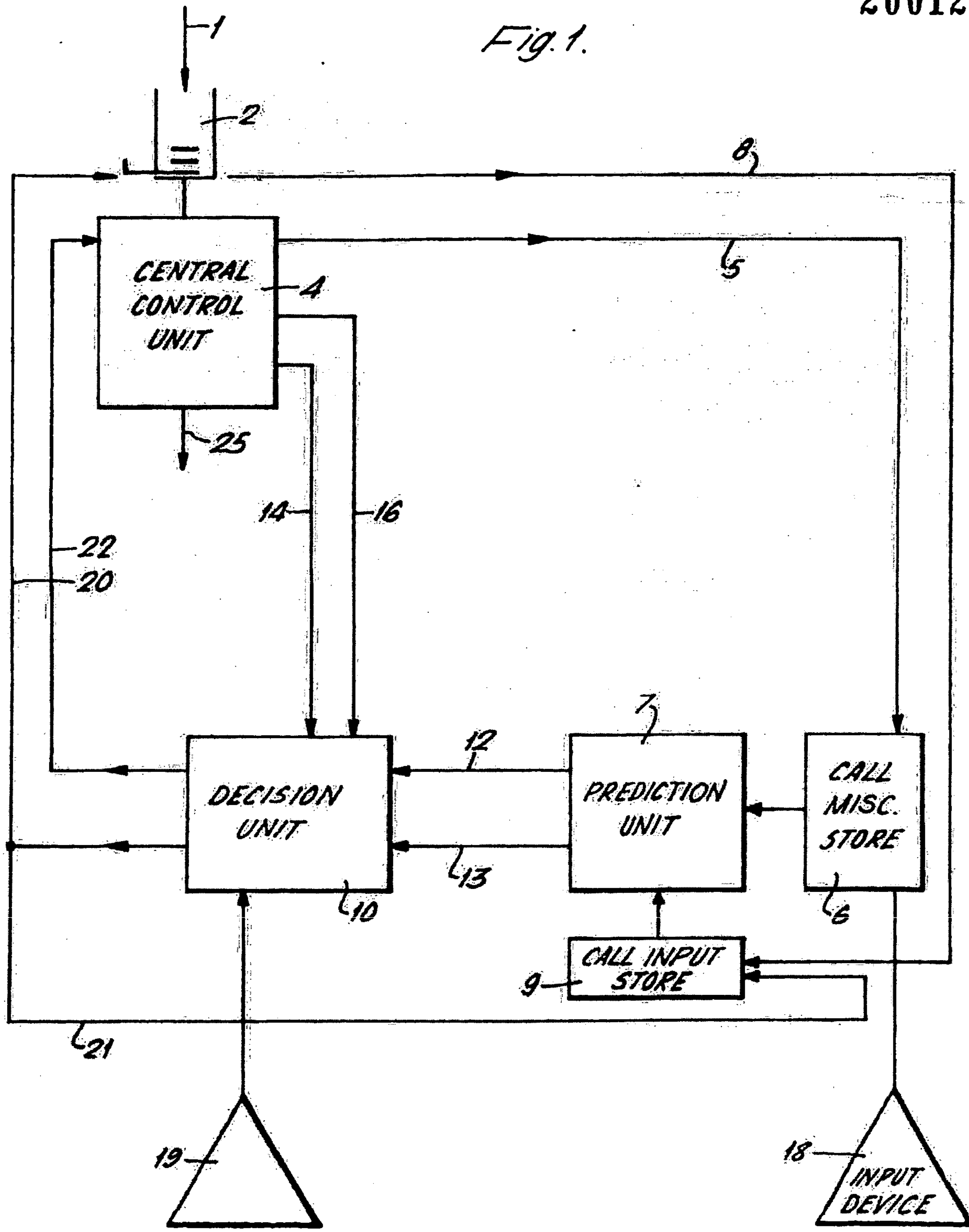
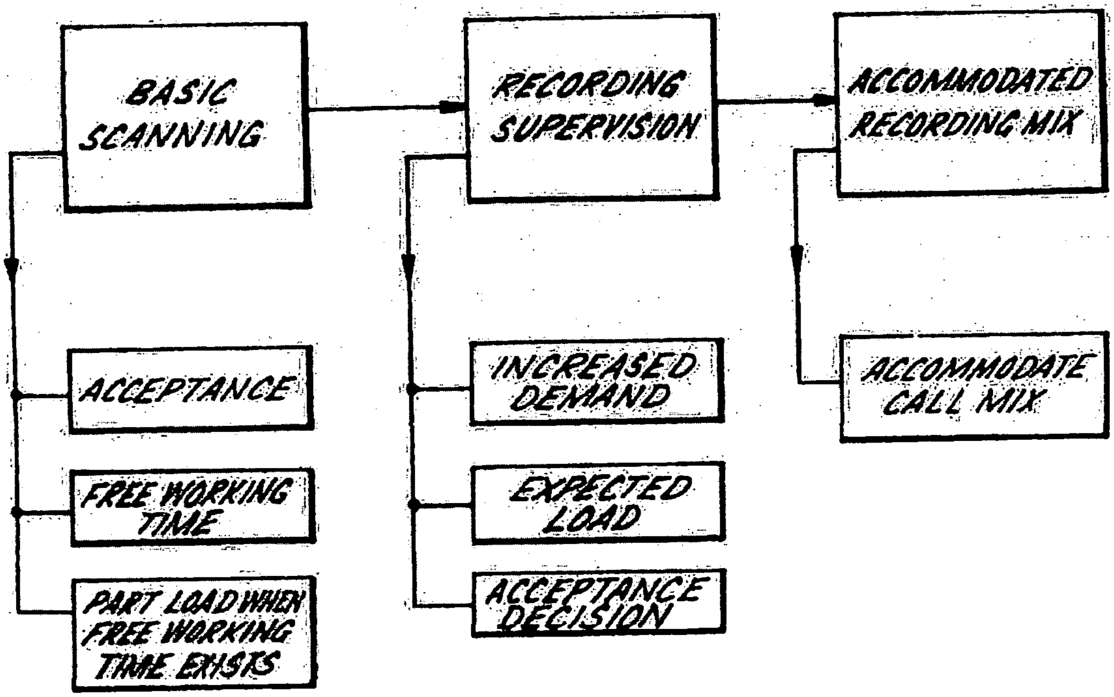
Fig.1.



1
2
8
CENTRAL CONTROL UNIT
4
5
25
14
16
22
20
DECISION UNIT
10
12
13
PREDICTION UNIT
7
CALL MISC. STORE
6
CALL INPUT STORE
9
21
19
18
INPUT DEVICE

Fig. 2.


BASIC SCANNING
RECORDING SUPERVISION
ACCOMMODATED RECORDING MIX
ACCEPTANCE
FREE WORKING TIME
PART LOAD WHEN FREE WORKING TIME EXISTS
INCREASED DEMAND
EXPECTED LOAD
ACCEPTANCE DECISION
ACCOMMODATE CALL MIX

SPECIFICATION

COMMON CONTROL TELECOMMUNICATION SWITCHING SYSTEM

This invention relates to a common control telecommunication switching system comprising a control unit and a decision unit which automatically limits that part of the incoming call attempts accepted for switching and, to avoid overloading of the central control unit, checks, at clock intervals, the number of call attempts accepted per unit time, and limits this number.

Such common control electronic telecommunication switching systems can only handle a given number of call attempts per unit time. To enable a computer forming the control unit to establish a requested connection, a sequence of control instructions must be executed at given times. During the execution of the individual instruction, maximum permissible waiting times must not be exceeded. If the system accepts too many call attempts, a lack of storage locations or a transgression of the maximum permissible waiting times causes a break in the sequence of control instructions or a mistreatment of a sequence. All work performed by the central control unit for such an unsuccessful switching operation is in vain, and the control unit was occupied needlessly. Thus it is necessary for the number of call attempts accepted per unit time be limited. The stochastically distributed incoming call attempts must be constantly supervised, since it is not only under overload conditions, but also in case of a normal load being placed on the switching system, that too many call attempts may arrive on a purely random basis and for short periods of time.

The central control unit can be protected from overload by limiting the number of call attempts accepted in a fixed time interval — e.g. in one second — to a fixed number which can be handled by the control unit with a high probability. Since, however, system occupancy is dependent not only on the number of call attempts accepted for switching but also on the type, composition, and time distribution of the call attempts, sufficient overload protection can only be ensured if a low average occupancy of the control unit is provided for.

In a known stored-programme-controlled telecommunication switching system (U.S. Patent 3,623,007), the instantenous occupany of the control unit is measured, and the number of call attempts accepted in a control interval is controlled dependent on the measured occupancy. The additional problems associated with the stability and hysteresis of a closed loop are alleviated by permitting the variation in the number of accepted call attempts in the control interval to take place only slowly and in small steps. Despite this occupancy-dependent control, however, an overload of the central control unit cannot be prevented with certainty since the delayed occupancy due to the already accepted call attempts is not regulated, and thus may also occur in a stochastic accummulation. On the other hand, it is also possible for a relatively high instantaneous occupancy of the control unit to cause a reduction in the number of accepted call attempts which then causes a very low occupancy of the control unit. In the known switching system, with large control intervals, traffic peaks are sometimes not sufficiently worked off, or, with small control intervals, waiting times may be longer than necessary.

An object of the invention is to provide a telecommunication switching system of the above-mentioned kind in which overloading of the central control unit is avoided, and in which occupancy during heavy traffic is constantly held in the range of the upper performance limit.

According to the invention there is provided a common-control telecommunication switching system including a control unit and a decision unit which automatically limits the number of incoming call attempts accepted for switching and to avoid overloading the central unit checks, at preset intervals, the number of call attempts accepted per unit time and limits this number, wherein associated with the decision unit there is a prediction unit which receives information as to the number of accepted call requests and which determines the currently-expected occupancy of the central control unit to be expected in a subsequent control interval with the aid of the received information and communicates such occupancies to the decision unit.

The principal advantages of the invention are that predictable overloads of the central control unit are avoided, that the occupancy of the control unit is levelled, and that the control unit can be constantly operated error-free at its upper load limit. In addition, the amount of control, computer and storage equipment required is small.

An embodiment of the invention will now be explained with reference to the accompanying drawings, in which Fig. 1 is a block diagram showing a common control telecommunication switching system embodying the invention, and Fig. 2 is a block diagram of the sampling control of the system of Fig. 1.

In Fig. 1, subscriber lines indicated at 1 are scanned successively at very short time intervals by means of a waiting facility 2 to determine whether there are any call attempts. This scanning process and all other tasks to be performed by the switching system are controlled by a central control unit 4. These tasks include, besides the "acceptance", i.e., the fixing of the number of call attempts to be accepted for switching per unit time, the call phases: pre-selection, dialling and signalling, through-connection, answer, and release. The central control unit performs these sequences of tasks, which are necessary to establish and release the desired connections, and the task sequences necessary to optimize the occupancy of the switching system, with the aid of fixed operational programmes, taking into account predetermined priorities.

In the above-mentioned call phases, information

on the measured partial occupancies is transferred from the central control unit 4 over a data line 5 to a call mix store 6, and from there to a prediction unit 7. Information on the number of call attempts accepted per unit time is transferred from the waiting facility 2 over a data line 8 to a call input store 9, and from there to the prediction unit 7.

The prediction unit 7 contains a memory organized as a matrix, which is associated with a decision unit 10, to which it supplies, over a data line 12, information on the currently expected occupancy of the central control unit 4, and, over a data line 13, information on the control unit occupancy to be expected in the subsequent control interval. The lengths of the different control and working intervals of the switching system will be dealt with below.

The decision unit 10 is supplied from the central control unit 4, over a data line 14, with measuring information on the total occupancy of the central control unit 4, and, over a data line 16, with measuring information on critical delays in the sequence of tasks performed by the central control unit.

Via an input device 18, a predetermined call mix, i.e., a predetermined breakdown of the call attempts according to origin, destination, and fate (degree of completion) can be entered into the call mix store 6. Analogously, a maximum permissible occupancy of the control unit 4 can be entered into the decision unit 10 via a second input device 19.

The unit 10 generates, in a manner to be described below, instruction signals which are transferred over a data line 20 to the waiting facility 2, where they determine the number of call attempts accepted for switching. Over a further data line 21, the output signals of the unit 10 control the occupancy of the call input store 9.

Under overload conditions to be described below, the decision unit 10 generates further control signals which are transferred over a data line 22 to the central control unit 4, where they initiate corresponding emergency task sequences.

The accepted call attempts are transferred from the waiting facility 2 over a connecting line 24 to the central control unit 4. The passing-on of the call attempts processed by the central control unit 4 is indicated by a connecting line 25.

The operation of the switching system will now be explained in greater detail.

The individual, successively occurring occupancy phases, due to the establishment and the release of a connection, begin with the preselection and end with the release, and result in the total occupancy of the central control unit, which is dependent on the input or request process.

The scanning of the condition of the subscriber lines, i.e., the determination of the incoming call attempts, causes a normal load to be placed on the central control unit 4 which is independent of the input process. By counting the requests for the individual task sequences — e.g. for preselection, dialling, etc. — the partial occupancies of the control unit by the different task sequences are constantly determined. These partial occupancies depend on the composition of the call attempts. The information about the partial occupancies is communicated to the call mix store 6 every K.M. τ sec, where τ is the basic clock interval at which the scanning of the call attempts and the essential task sequences of the central control unit are carried out, and K and M are fixed integral factors for the clock periods of less frequently performed task sequences. The information in the store 6 determines in this store the call mix parameters. If no measured data are present, or other parameters are to be used, a standard call mix is entered into the store 9 via the input device 18. The call input store 9 also associated with the prediction unit 7, is fed from the decision unit 10 only with the input process information necessary to predetermine the expected occupancies of the central control unit 4.

The unit 4 constantly determines the share of free processing time and the number of waiting periods of a given critical task sequence of low-level priority, and sends corresponding information to the unit 10. An undue delay in the individual task sequences in the unit 4 could result in a misinterpretation of call numbers, and this must be avoided. When the number of waiting periods exceeds a predetermined maximum permissible number, the decision unit 10 gives an instruction which initiates in the central control unit 4 an emergency task sequence which reduces the normal load presented to the unit 4, the scanning process being interrupted for a given time, and independent task sequences of no urgency being broken off.

During normal operation, the unit 10 — dependent on the communicated predetermined maximum occupancy which can be expected if the input process is not subjected to any major changes — determines the number of call attempts to be accepted in a control interval. This ensures than an increased stock of requests as would result from the number of call attempts to be accepted is not likely to lead to an overload of the central control unit at a later time.

For stability reasons, the call mix parameters are adapted to the varying partial occupancies of the central control unit 4 relatively slowly. In addition, a sudden change in the type and composition of the call attempts may cause an unforeseen increase in the occupancy of the control unit 4. To prevent such an overload, if the instantaneous occupancy, determined via the free processing time of the central control unit, exceeds the expected occupancy by at least ten per cent in more than two successive control intervals, the number of accepted call attempts is reduced by twenty per cent as a precaution. If, however, the actual occupancy exceeds the permissible occupancy limit, an emergency task sequence is initiated for a few control intervals which stops the acceptance of call attempts and reduces the normal load placed on the unit 4.

The prediction matrix contained in the unit 7

takes into account the specific features of the switching system and consists of the following storage locations:

P_0, P_1, P_2
$D_0, D_1, D_2, \ldots D_{35}$
$S_0, S_1, S_2, \ldots S_{44}$
$A_0, R_0, O,$

where the symbols P denotes the task sequence "preselection", D "dialling, signalling", S "through-connection", A "answer", R "release", and O the "normal load". The subscripts designate the consecutive, systematic transfer of the contents of the individual storage locations, the number of the storage locations for the different task sequences corresponding to the given and expected time delays, counted from the preselection, and to the duration of the occupancy for this task sequence.

The parameters of the call mix are assigned the following storage locations which, for simplicity, are designated by the following capital letters in accordance with the task sequence:

P, D, S, A, R.

These parameters are a measure of the expected task densities in the unit μs processing time per call attempt and per interval τ.

The contents of the call input store 9 are adapted to the input process. The transfer is effected every $K\cdot\tau$ sec by the transfer procedure given below, where L is the number of call attempts accepted in the last control interval. The equations should be read as follows: $P_0=P_1+L$, for example, means: "Take contents of storage location P_1, add the number L, and store the result in storage location P_0".

$P_0=P_1+L$
$P_1=0{,}5\cdot L$
$P_2=0{,}99\ P_2+0{,}01\cdot L$
$D_0=D_1$
$D_1=D_2$
$D_2=D_3+L$
$D_3=D_4+L$
$\vdots$
$D_{34}=D_{35}+L$
$D_{35}=L$

$S_0=S_1$
$S_1=S_2$
$\vdots$
$S_{34}=S_{35}$
$S_{35}=S_{36}+0.1\ L$
$S_{36}=S_{37}+0.3\ L$
$S_{37}=S_{38}+0.5\ L$
$S_{38}=S_{39}+0.8\ L$
$S_{39}=S_{40}+L$
$S_{40}=S_{41}+L$
$S_{41}=S_{42}+L$
$S_{42}=S_{43}+0.8\ L$
$S_{43}=S_{44}+0.5\ L$
$S_{44}=S_{45}+0.3\ L$
$S_{45}=0.1\ L$

$A_0=0.99.A_0+0.08\cdot L$
$R_0=0.99875R_0+0.0175\cdot L$

As mentioned, the call mix parameters are transferred only slowly (i.e., every $K\cdot M\cdot\tau$ sec, the parameters are changed by a maximum of 20%) as follows:

$P=0.8P+0.2P'$	Initial values:	$P=16$
$D=0.8D+0.2D'$	input of the	$D=1.5$
$S=0.8S+0.2S'$	standard call	$S=8$
$A=0.8A+0.2A'$	mix	$A=8$
$R=0.8R+0.2R'$		$R=14$

where the primed letters represent the new values determined via the measured partial occupancies of the central control unit.

The prediction matrix of the unit 7 contains a simulation configuration of the occupancy of the unit 4, and this simulation configuration determines the occupancy of the control unit.

The occupancy expected at a particular instant is determined by working off the orders on hand:

$$C_0=(0+P\cdot P_1+D\cdot D_0+S\cdot S_0+A\cdot A_0+R\cdot R_0)K_G$$

where K_G is a normalization constant (e.g. 1/1000 sec/μ sec), so that C_0 represents a dimensionless occupancy share.

A mean call intensity is determined every τ seconds by the following transfer:

$$L_0=0.95\cdot L_0+0.05L$$

The occupancy D_{Ei} for "dialling" is predetermined for the i-th future interval as follows ($i\leq 32$):

$$D_{Ei}=D_i+(i-2)L_0,\ i>1$$

Let the upper occupancy limit be B. The first limitation of the number of accepted call attempts is determined by the "preselection":

$$L_p = \frac{1}{P}\ (B-C_0)$$

To prevent the task sequences "dialling", "signalling" and "through-connection" from causing too high an occupancy of the central control unit 4, the following values are fixed:

$$S_M=\max\{S_{41}+3.7L_0,\ S_{40}+2.7L_0,\ S_{39}+1.7L_0\}$$

$$D_M=\max\{D\cdot D_3+S\cdot S_3,\ D\cdot D_{E4}+S\cdot S_4,\ D\cdot D_{E5}+S\cdot S_5\}$$

$$L_S=\frac{1}{S}\cdot[B-(0+D\cdot 34L_0+P\cdot 1.5L_0+A\cdot A_0+R\cdot R_0)]-S_M$$

$$L_D = \frac{1}{D}\cdot[B-(0+D_M+P\cdot 1.5L_0+A\cdot A_0+R\cdot R_0)]$$

The smallest of the values of L_P, L_D and L_S so formed represents an indication of subsequent processing bottlenecks which can, in all probability, be avoided if the decision unit 10 is designed so that the number of call attempts to be accepted in the control interval having started — unless an emergency task sequence is initiated — satisfies the equation

$$L' = \mathrm{Min}\,(L_P, L_D, L_S).$$

The emergency task sequences are initiated as follows: let us assume that a free processing time share F has been measured for the central control unit 4. If

$$\frac{1-F-C_0}{1-F} > 0.1,$$

In more than two successive control intervals, operation with a number of accepted call attempts reduced by 20% will be initiated as a precaution,

$$L' = 0.8 \cdot L',$$

and currently unnecessary operations of the central control unit 4 will be deferred. If the aforementioned critical task sequence is delayed by more than $3 \cdot \tau$ sec, an instruction from the decision unit 10 will initiate a break in the acceptance of call attempts for at least three control intervals and interrupt the scanning process. The emergency task sequence will be discontinued after three control intervals at the earliest when $1-F<B$, i.e., when the occupancy of the central control unit 4 has fallen below the maximum permissible limit.

The length of the control interval and that of the call mix adaptation interval are determined by the capacity of the central control unit 4. They must be chosen so that not more than about 1% of the processing time of the central control unit is expended on the control function in the state of high occupancy. Thus, the lengths of these intervals are fixed as follows: $K=10 \ldots 20$ and $M=10 \ldots 20$.

Fig. 2 is a block diagram of the sampling control of the telecommunication switching system according to the invention. It shows the sampling and scanning sequences, which have different cycle times.

After every basic sampling interval of, e.g., 15 to 25 ms, the subscriber lines are scanned for the presence of call attempts, the free processing time of the central control unit is determined, and, if there is free processing time, the partial occupancies of the central control unit are determined by the individual switching sequences.

After K-times the basic sampling interval, the occupancy of the central control unit 4 is supervised, the number of call attempts to be accepted is fixed, and the expected occupancy is determined.

Every $K \cdot M \cdot \tau$ (τ=15 to 25 ms), the parameters characterizing the call mix are adapted.

The devices controlling the telecommunication switching system according to the invention are described in the foregoing as permanently wires circuits. They may also be implemented in the form of operational programmes permanently stored in the working memory of a central control unit 4 designed as a central processor.

CLAIMS

1. A common-control telecommunication switching system including a control unit and a decision unit which automatically limits the number of incoming call attempts accepted for switching and to avoid overloading the central unit checks, at preset intervals, the number of call attempts accepted per unit time and limits this number, wherein associated with the decision unit there is a prediction unit which receives information as to the number of accepted call requests and which determines the currently-expected occupancy of the central control unit to be expected in a subsequent control interval with the aid of the received information and communicates such occupancies to the decision unit.

2. A common-control telecommunication switching system including a control unit and a decision unit which automatically limits the number of incoming call attempts accepted for switching and to avoid overloading the central control unit checks, at clock intervals, the number of call attempts accepted per unit time and limits this number, wherein the decision unit is assigned a prediction unit which receives information on the distribution of the number of accepted call attempts and on the call mix, and which determines the currently-expected occupancy of the central control unit and the occupancy of the central control unit to be expected in a subsequent control interval with the aid of the received information, and communicates these occupancies to the decision unit.

3. A system as claimed in claim 1, wherein the prediction unit is assigned a call mix store which receives information on the partial occupancies of the central control unit due to individual switching phases of the call attempts.

4. A system as claimed in claim 3, wherein the information to be received in the call mix store is data to be transferred from the central control unit.

5. A system as claimed in claim 3, wherein the information to be received in the call mix store is predetermined data.

6. A system as claimed in claims 2, 3, 4 or 5, wherein the prediction unit is assigned a call input store which receives information on the call attempts accepted for switching.

7. A system as claimed in any one of claims 2 to 6, wherein the prediction unit contains computing devices which determine the occupancies of the central control unit.

8. A system as claimed in any one of claims 2 to 7, wherein the decision uinit contains comparing devices which compare the currently expected

occupancy of the central control unit with the measured occupancy of this unit, and the occupancy expected in the subsequent control interval with a predetermined maximum occupancy.

9. A system as claimed in claim 8, wherein the decision unit contains computing devices which fix the number of call attempts to be accepted in the subsequent control interval on the basis of the results of the comparisons and of the predetermined maximum occupancy of the central control unit.

10. A system as claimed in claim 9, wherein the decision unit includes an extrapolation device which determines the occupancy to be expected in the subsequent control interval.

11. A system as claimed in any one of claims 2 to 10, wherein the decision unit includes a protective device which reduces the normal work load placed on the control unit as well as the number of call attempts acceptable in the subsequent control interval if the measured instantaneous occupancy exceeds the expected occupancy in a predetermined manner.

12. A system as claimed in any one of claims 2 to 11, wherein the decision unit includes an emergency control which reduces the normal work load placed on the control unit when a critical load is exceeded.

13. A telecommunication switching system substantially as described with reference to the accompanying drawings.

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